Chemistry Quiz
Atomic Structure and Periodicity
Instructor's Version

Answers to Section I (Multiple Choice)

1.	**D**
2.	**A**
3.	**C**
4.	**C**
5.	**E**
6.	**D**
7.	**C**
8.	**B**
9.	**B**
10.	**B**

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Answers to Section II (Free Response Questions)

1. Neils Bohr deduced his "planetary model" of the atom from data of the line spectrum of a hydrogen atom. It was very successful in justifying the empirical relationships of the data but did not work for atoms larger than hydrogen. Schrödinger's wave function equation modified the Bohr model to account for the splitting of energy levels. We now have quantum numbers to describe the placement of electrons in an atom.

A. What are Bohr's theoretical connections between the energy level transitions of an electron and the specific color of a photon in the hydrogen line spectrum? (10 points)

Answer:
The answer should indicate that: (2 points each)

- The lines on the spectrum are made by photons of different frequency and/or wavelength.
- The photons thus represent different quanta of energy (amounts of energy is acceptable).
- The different quanta of energy result from electrons moving from a higher energy state to a lower one ("falling" from higher level to lower is acceptable).
- Electrons can only exist in these discrete energy states (levels) because only specific energy photons are shown in the line spectrum ("fixed orbits" is okay).
- Electrons move to a higher energy state (level) when they absorb energy and down to a lower state (level) when they release a photon.
- * "Electrons do not emit energy when in stationary states" is not required for full credit, but can be given 2 pts if something else is left out.

B. Please explain the advantages in the modern quantum mechanical model over the Bohr model. Use the following concepts in your answer: Heisenberg Uncertainty Principle, quantum numbers, orbital, sublevel, Hund's Rule, Pauli Exclusion Principle. (20 points)

Answer:
The answer should include the following: (2 points each)

Bohr model	Quantum model
Worked only for hydrogen	Works for all known elements
Electrons travel in fixed "orbits"	Electrons are located in probability regions
Electrons had only energy levels	Electron was identified by four quantum numbers
	Speed and direction of the electron can not be known at the same time (Heisenberg Uncertainty Principle)
	One electron in each orbital in a sublevel before doubling up electrons (Hund's rule)
	Electrons in the same orbital must have opposite spin (Pauli Exclusion Principle)
	Location of an electron includes sublevels and orbitals

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2. The general trend in ionization energy shows an increase moving from left to right on the periodic table. There is a temporary change in this pattern when we move from group IIA to group IIIA, as with beryllium and boron.

A. Use the quantum model to explain why this general trend appears. (15 points)

Answer:
The following scoring rubric can be used: two points each except for the first one, which is worth three points as noted. They can be given in any order.

- Ionization energy is the measurement of the energy needed to remove the most loosely held electron in an atom. (3 points)
- The higher the ionization energy, the more effective the nucleus is at attracting its outermost electrons.
- The increase in the number of protons as we move left to right on the table makes the nucleus have a greater charge.
- The number of shells of electrons does not increase across the period.
- The number of shielding electrons remains constant.
- The electron-electron interaction of electrons in the same energy level is not as significant as the inner electrons.
- Thus the outer electrons are generally held more and more tightly as we move across the table.

B. Please use orbital diagrams with your explanation of why the specific interruption occurs. (15 points)

Answer:
The answer should include all of the following:

- Group IIA elements have a full s sublevel in their outer shell. (2 points)
- Group IIIA elements have a full s sublevel and one electron in the p sublevel in their outer shell. (2 points)
- The orbital diagram of beryllium (or another IIA element) is 2s: ↑↓ 2p: __ __ __. (3 points)
- The orbital diagram of boron (or other IIIA element) is 2s: ↑↓ 2p: ↑ __ __ . (3 points)
- The electrons in the 2s subshell are of slightly lower energy than those of 2p, thus it is easier to remove the p electron than an electron from an s subshell. (3 points)
- The splitting of the energy level due to electron-electron interactions result in increased repulsion of the 2s electrons on the 2p electron, making it easier to remove. (2 points)

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